Circular No. 28.

United States Department of Agriculture,

DIVISION OF BOTANY.

RUBBER CULTIVATION FOR PORTO RICO.[1]

After sugar and coffee, rubber is the most important commodity of vegetable origin now imported into the United States, our receipts during 1899 being valued at $32,500,000. The anticipation of an exhaustion of the natural supply by the constantly increasing demand, accompanied by ever-ascending prices, now ranging between 50 cents and $1 per pound, has continued to stimulate interest in the future of rubber as an agricultural crop.

The tropical colonies of England, France, and Holland, were first aroused, but the recent acquisition of tropical territory by the United States has turned the attention of many Americans to tropical agriculture with the unknown possibilities of rubber culture as one of the most alluring branches. Many newspaper and other articles have been written advocating immediate steps toward the cultivation of rubber in Porto Rico, Hawaii, and the Philippines, and numerous requests for information and advice on the subject have been received by this Department.

The extent to which the wild supplies of rubber are exhausted is, as yet, entirely uncertain. The regions from which the largest contributions now come, the tropics of Africa and South America, are still largely unexplored, geographically as well as botanically, and the discovery of new areas of rubber-bearing vegetation, as well as of new rubber-producing species, is of frequent occurrence and may continue at the present rate for many years. But as the regions drawn upon become more inaccessible and the demand becomes more extensive, the rise in prices may be expected to continue until the production of rubber by agricultural or other artificial means has been placed on a scientific and industrial basis.

Perhaps the greatest danger to which an agricultural industry based on rubber would be subject, is the perfection of the accidental discovery that rubber may be formed synthetically from turpentine. Although the fact was announced in 1892, no progress is known to have been made in hastening this process of formation of artificial rubber, which is too slow and uncertain to be of practical value. But since a slight increase in chemical knowledge might at any time change the whole situation, this possibility should be recognized by those who propose to risk their resources upon rubber cultivation,

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[1] The matter contained in this circular was written as part of a report, now in preparation, on the useful plants and agricultural possibilities of Porto Rico. The separate publication of this portion is intended as a means of replying to numerous inquiries on the subject of rubber production as an agricultural industry.—Frederick V. Coville, *Botanist.*

although the danger may prove to be remote. In any case it will affect to a far less degree the farmer or planter who may grow rubber, as suggested later, as an accessory to other lines of agricultural production, and thus avoid a large part of the expense and risk attending enterprises based on rubber alone.

BOTANICAL SOURCES OF RUBBER.

In the discussion of rubber from the agricultural standpoint, it is of the utmost importance to keep in mind a primary fact very generally overlooked by the interested public. Rubber is not like wheat, apples, or coffee, the product of a single botanical species or group of closely allied species; it is comparable rather to sugar, a substance, or rather a series of similar substances, obtainable from a great variety of plants, belonging to different botanical families, native in different parts of the earth and requiring utterly different conditions for their successful cultivation. Thus sugar exists in the juices of a large number of species and has been commercially obtained from the sugar cane, the sugar beet, and the sugar maple, the grape, the date, and the Palmyra palm.

Similarly, substances marketed as rubber and gutta percha are known to exist in the milky juices of nearly two hundred plants belonging to botanical families quite as remote from each other as the sugar cane and the beet, or the palm and the maple. Rubber culture becomes, therefore, a very complex problem, and one very much in need of a thorough investigation; for concerning many of the rubber-bearing plants very little is known, even the botanical identity being frequently in doubt, to say nothing of the deficiency of all information concerning their adaptability for cultivation.

While it is thus impossible to determine in advance the possibilities of rubber cultivation in Porto Rico, it is desirable, nevertheless, to consider the prospects there of some of the rubber plants which have been investigated from the cultural standpoint.

PARA RUBBER (*Hevea brasiliensis*).

To the cost of numerous experimenters, it has been found that the fact that a rubber-producing tree will flourish in a given locality is not a trustworthy indication that it will yield a profitable quantity of rubber, and many hopeful and widely advertised enterprises have thus met with more or less complete failure. As might have been expected, the first attempts at rubber culture were made with the plants best known as furnishing the wild supply. Preeminent in this respect is the Para rubber tree, *Hevea brasiliensis*, with reference to both quality and quantity of product. This is a rather slender forest tree of moderate size, native in the valley of the Amazon, and especially in the vicinity of Para, whence much of the crude gum is shipped. For many years its cultivation has been

advocated in view of the constantly increasing demand and anticipated decrease of supply. The East Indian plantations have generally refused, however, to become remunerative, although in some cases effort was made to duplicate exactly the conditions under which the tree thrives in Brazil. It is now known that even in Brazil the amount of rubber decreases and the quality of the product becomes inferior outside the localities where extensive annual inundations occur, although the tree appears to thrive with undiminished vigor in drier situations, and other species of Hevea grow normally in localities not subject to floods.

In Ceylon trees of Hevea are yielding some returns from the sale of seeds, but no plantations have as yet become remunerative by the production of rubber. In the Straits Settlements the outlook is said to be more hopeful for plantations of Hevea located in very wet places. Mr. David G. Fairchild, Agricultural Explorer of this Department, states in a recent letter that fair amounts of rubber of prime quality are being obtained. Two pounds of rubber a year are expected from trees five or six years old, and extensive plantings are being made. In Java, however, where the organization of agricultural enterprises has reached a high degree of perfection, and where Hevea and other rubber plants have received more extended experimental attention than elsewhere, the planting of Para rubber as a regular crop is no longer considered advisable, this view being the result of recent careful study on the part of agricultural specialists. For Java *Ficus elastica* is deemed the most promising of the rubber-producing species, but even on the general question of the profitableness of rubber plantations, the Dutch investigators are said to have come to an adverse conclusion, largely on account of the fact that the competent and honest administration of the estates is a proportionally much larger element of expense in tropical than in temperate countries, a consideration which has been very generally overlooked in preparing the estimates widely circulated in the prospectuses of the various rubber-planting stock companies.

CEARA RUBBER (*Manihot glaziovii*).

As a reaction from the failure of Hevea, attempts were made with the Ceara rubber tree, which grows wild in northeastern Brazil, in rather open country, subject to a severe and extended dry season. To the further loss of the over-sanguine investor, it has been found that this species is similarly unproductive under changed conditions. In none of the experiments made thus far in Ceylon and other parts of the East Indies has success been attained in the commercial production of Ceara rubber. The failure is supposed to be due in this instance to too great humidity of climate, though other factors may be involved. This species was supposed to have the further advantage of very rapid growth, thus permitting the trees to be tapped in from

three to five years after planting the seed. It is now found, however, that the quick growth takes place only during the early life of the tree, which never attains to very large size, and continues to yield only small quantities of rubber, from one to three ounces per year, although a considerably larger amount, from one to three pounds, is claimed in the original South American habitat of the species. As a shade tree for cacao or other crops Ceara rubber is also useless, since it rapidly exhausts the soil and permits nothing to thrive under it. Some planters who set their trees in rocky waste places consider it worth while to harvest the rubber, although this process is relatively expensive, estimated as high as 36 cents a pound, from the fact that the amounts yielded by ordinary incisions are very small—mere "tears," as they are called. As a cultural crop Ceara rubber is generally considered a failure at the present time, and many plantations, some of large size, have been cut down and destroyed. In view of the continued rise in prices it is not, however, impossible that in some localities with the correct natural conditions, and where there is an adequate supply of cheap labor for harvesting the rubber, *Manihot glaziovii* may still be of value. On the drier south and southwest slopes of Porto Rico there are tracts of land not utilized at present where experimental plantings might well be made. It seems certain, however, that under conditions at all favorable Hevea will make, in the course of ten years, a larger growth and produce more rubber than Manihot.

CENTRAL AMERICAN RUBBER (*Castilloa elastica*).

A third rubber tree, native from Mexico to Bolivia, is now being cultivated in Central America, and with somewhat better promise of success. Although the quality of its rubber is inferior to that of Hevea, the quantity is larger and the trees may be tapped at an earlier date. The use of Castilloa as a shade tree for coffee plantations has been advocated, but recent testimony seems to indicate that as little is to be expected from the rubber when planted in situations favorable to coffee as from coffee when planted in the rubber belt. Indeed, for best results the rubber trees are said by some to require shade, with which a pound of rubber per tree from plantations nine or ten years old may be expected. In Guatemala it has been figured that the first crop from a plantation involving an expenditure in ten years of about $42,000 would pay the expenses of harvesting and leave a surplus of about twice the preliminary outlay, including interest on funds invested. This calculation is, however, like much of the information furnished by promoters, suspiciously moderate in its estimates for labor, management, and other details.

The case is not at all comparable to that of coffee, in which Mexican and Central American investments have been popular. Coffee

thrives in elevated regions which may furnish a salubrious and enjoyable climate, but the successful cultivation of Castilloa, or at least the possibility of returns within a decade or two, seems to require thoroughly tropical and decidedly insalubrious conditions. Without an annual rainfall of 150 to 200 inches, and an average temperature of from 90 to 100 degrees, paying crops of rubber are not to be expected under twelve or fifteen years. Whether trees grown outside such conditions will produce well when once they have reached the proper size is not yet known, but the analogy of other experiments renders it improbable.

If it be remembered, then, that the work must be carried on in an insalubrious climate, where labor is scarce and uncertain, to say nothing of other vicissitudes to which such an undertaking is necessarily subject, it does not appear probable that many men having the capital necessary to start an enterprise large enough to be economically conducted will be willing to invest and wait so long a time for the returns. The average American capitalist who will consider agricultural investments expects rather to turn his money over every year or two, with a considerable increment.

The latest information regarding the rubber situation in Mexico is contained in a recent consular report and is entirely confirmatory of the above view. Land suited to the growth of rubber is said to be obtainable at from $1.00 to $15.00 per acre and is covered with dense jungle. From 150 to 300 trees are set per acre, and these may be tapped in from five to fifteen years, depending upon the soil, temperature, and rainfall. Thoroughly tropical conditions are best, and under these a tree is said to yield an average of from one to two pounds of rubber per year, at present valued at about 67 cents. The rubber regions are thinly inhabited, doubtless because insalubrious and are remote from centers of populations. Oriental labor must be be imported, and wages approximating fifty cents a day are paid. Living in civilized fashion is described as much more expensive than in the United States.

This goes to show that, even under the most favorable conditions, the culture of Castilloa rubber offers many difficulties which can not be reckoned with in a simple estimate. Whatever be the real merits of this particular culture when carried on under the most favorable circumstances, it should be recognized that, like that of Hevea, it requires a climate more thoroughly tropical, hot, humid, and insalubrious than any part of Porto Rico, where the only land likely to prove at all suitable is that now planted in sugar and valued at from $75 to $200 per acre.

RUBBER CULTURE AS AN ELEMENT IN MIXED FARMING.

The situation in Central America has been explained at some length because rubber plantations are now being widely advertised

as opportunities for profitable investment, very frequently in connection with unreliable data. Estimates published a quarter of a century ago, when rubber culture was first suggested, are still quoted in prospectuses as demonstrated facts, although their authors have long since repudiated them. This does not mean that rubber cultivation may not become an extensive and profitable industry, which there is every reason to expect. It is desired rather to call attention to the elements of uncertainty entering into the business and to warn the public against ill-advised ventures which are justified by no ascertained facts. Although rubber culture on any plans yet tried may not be found profitable in Porto Rico or in other countries where the population is large and the land valuable, the potential agricultural wealth of such regions might be increased by many millions by the planting of rubber trees for shade along roads, in pastures, and in waste places generally, wherever they will not interfere with anything more valuable. Even though the conditions may not be the best, nor the culture remunerative to such a degree that capitalized stock companies could pay for land, labor, and management, and still secure dividends on their investments, there is every prospect that the farmer who is maintaining himself by other means may reap excellent results by gradually replacing worthless vegetation with valuable, the ultimate gain depending, of course, upon the price of rubber, which seems likely to increase indefinitely, pending the invention of an artificial substitute or the discovery of better plants or superior methods of culture and extraction.[1]

[1]An illustrative instance of the danger likely to beset investments in rubber comes to hand as this circular is being sent to the printer. A well-known journal notices a new substitute for rubber, describing it as a gum obtained by grinding up the bark and "comparatively hard wood" of a "small scrubby bush," and then macerating in gasoline or other hydrocarbon solvent. "By this process the gum that comes out is chemically pure and suitable at once for manufacture, and it forms a new composition consisting of resin of the plant combined with a residual portion of the hydrocarbon solvent." The shrub, which has no milky juice, is said to grow in abundance on the "rolling land" of Central Mexico, is readily propagated, may be cut two or three times a year, may be treated when fresh or dried for export, and yields by weight 40 per cent of a gum "superior to most india rubber," and having the additional advantages of abundance, cheapness, and ease of manipulation. The Indian name is said to be "yule," already known in application to *Castilloa*, while the scientific designation, "Synatherecœas-Mexicanas," seems to have been unfortunately chosen, since the genus Synantherias, which has the only similar name known to botanists, is a member of the aroid family, like the Indian turnip and calla-lily, and represents a succulent East Indian herb, not a Mexican shrub. Moreover, it is by no means clear how the "comminuted shrub" without other provision than straining through a canvas bag for the separation of the 60 per cent of waste matter can be expected to issue in the "chemically pure" condition, since the oils, fats, resins, and many other vegetable substances would be incorporated by the solvent. Neither could such a process be carried out on fresh material, the water of which would prevent the action of the solvent. Similar inaccuracies are frequent in claims and applications for patents for artificial rubber substitutes, the published accounts of which are sometimes intended to draw public attention without unduly enlightening trade competitors. Naturally, the knowledge of any such new source of wealth, or of a process by which a hitherto worthless natural product may be exploited, generally results in the greatest secrecy on the part of the first possessors of the information.

EXPERIMENTAL PLANTINGS OF RUBBER TREES.

There are, as previously stated, a vast number of rubber plants already known, and doubtless as many more remain to be discovered. What is now greatly needed is a canvass of these species with reference to the conditions in which they are native and their adaptability to cultivation. In size they range from herbs through shrubs and vines to large forest trees; in habitat there is also every gradation between swamps and deserts. Experience with Hevea and *Manihot glaziovii* indicates the necessity of close approximation to natural conditions if good results are to be expected. It may be found that some species will prove less sensitive; but large investments on such a supposition are certainly not advisable.

The well-known "rubber plant," *Ficus elastica*, in common use for decorative purposes, thrives in Porto Rico and grows to a large size, though the wood is soft and the trees suffered in the hurricane. Plantations of this tree, while requiring from fifteen to twenty years to reach full bearing, have proved profitable in the Malay Peninsula. In West Africa a very similar and equally beautiful native species, *Ficus vogelii*, like many other members of the genus, is also known to yield rubber. *Ficus pedunculata* and three or four others are already growing wild in Porto Rico or are planted for shade. The amount of rubber obtainable has been found to be small, but more might perhaps be secured by tapping in the rainy season. The figs have the advantage of growing readily from cuttings, and there are other rubber-yielding trees which may be propagated in this way. In Madagascar an apocynaceous tree has recently been discovered which spreads itself readily by means of suckers rising from the ground; and thus the species is not exterminated, although individual trunks are cut down to secure the milk.

Recently a rubber plant from the Andes, *Sapium biglandulosum*, has been brought to public attention, and seeds are being sold by dealers. An experiment with this should be made in the mountains of Porto Rico, where its cultivation might be carried on in connection with that of coffee, if found profitable.

There are many other alluring possibilities which have been or might be suggested, but all are still in the experimental stage, to say nothing of the fact that Porto Rican conditions are entirely untried. In order to meet in advance this last difficulty, and to make possible the early provision of seeds and propagating stock whenever the utility of a species can be demonstrated, it is eminently desirable that a collection of rubber-producing plants be maintained in Porto Rico, and that it be begun at the earliest possible date. The seeds of many tropical trees are extremely short-lived and will not withstand drying. By special packing or shipment in Wardian cases, in which

they can germinate en route, it may be possible to send them long distances, but such shipments, as well as those of young plants, are expensive and unsafe, and the vitality of the seedlings is often injured when not entirely destroyed, thus partially vitiating experiments and rendering it impossible or extremely costly to import large quantities of desirable seeds in case a general demand should arise for a particular species. Viewed from the standpoint of the utility of rubber for those who may undertake intelligent mixed farming in the tropics, it will be worth while for owners of plantations to begin experimental plantings of the most promising rubber trees now known and of others as fast as they are announced by explorers and experimenters. Without such local experiments the desirability of more general planting can not be known with sufficient certainty to justify large expenditure or the use of valuable land, should the industry reach the point where this would be advisable anywhere in Porto Rico.

HARVESTING OF RUBBER.

The question of rubber cultivation is not complicated alone by the number of different species involved and their varied requirements for the production of the largest quantity of milk. The work of drawing the milk and extracting the rubber is, and will undoubtedly remain, a large element of labor and expense which can not be overlooked with safety in planning for the inauguration of a new industry. In the collection of the wild supply, the practice of cutting down the trees or vines for the sake of the milk which drains out of the severed parts has been general, but even the savages have in some instances seen the advantage of not destroying so valuable an asset, and various processes of tapping have been resorted to. In many cases these are but a slight improvement over the former method, since the injuries are so severe as to seriously weaken the tree, while its wood is exposed in deep gashes to the attacks of destructive fungi and insects.

To secure maximum profits, cultural attempts with rubber must be combined with improvements in methods of harvesting, the yield of the rubber orchard for any one season being entirely secondary to the question of its perpetuation and continued productiveness. Some trees yield their milk freely, while others exude but little and must be repeatedly tapped, necessitating much greater labor in collecting. In some the bark closes readily, while in others injury is more permanent, and new places must be tapped each season. The advantages of longitudinal, oblique, and transverse cuts have also been considered, but mostly from the standpoint of the wild trees, where the maximum yield without actual destruction is usually the limit of

caution. Various improved axes and knives have been devised, but most of these have been adversely reported upon in practice, and none has come into general use.

A general fact of practical importance may, however, be noted. Under cultural conditions the expense of collecting the milk will be increased, since the continued health of the trees will necessitate the extraction of smaller amounts of milk, with the use of better tools and the exercise of more care in the process, all of which means more, as well as higher-priced, labor. There may, of course, be compensating advantages if tools of sufficient excellence can be invented, and also in the fact that the trees will be closer together than is usual in the wild state. But labor employed in a civilized community is, in any event, likely to be much more expensive than that now utilized in the work of rubber gathering, most of which is performed in their own unvalued time by the natives of uncivilized regions, who barter the product for manufactured articles which are to them merely luxuries.

COAGULATION OF RUBBER.

No less great are the needs of investigation and the attendant possibilities of progress in the matter of extracting rubber from the milk. It is in this department that the increased expense of drawing and collecting the juice may be compensated in regular culture by the better opportunities for applying improved methods of extraction, which will secure all the rubber and render a product of the best quality. If necessary, all the milk of an orchard or of a whole agricultural section might be treated at one establishment—a rubber dairy, so to speak.

The latex of rubber-producing trees is quite analogous to animal milk in that it consists of a liquid in which float minute globules of a different composition which tend to separate as soon as the physical or chemical conditions of the suspending fluid are changed. The term coagulation is accordingly applied, although the underlying changes may be entirely different, not only in milk and rubber, but also in the different kinds of rubber. The latex of some trees separates immediately on exposure to the atmosphere, and a drop taken between the thumb and finger will show at once fine elastic strands. The natives of Angola are thus able to gather considerable quantities of rubber from Landolphia simply by smearing the juice over their bodies. After coagulation has taken place the gum is peeled off in sheets which are considered of good quality by the trade. Ceara rubber, also, receives no special treatment; the milk is allowed to dry on the tree or run down its side and collect in little hollows in the ground, protected from the soil only by a few leaves.

The Para rubber does not so readily coagulate, and is caught in small clay cups which are plastered to the trees with mud. The latex is then collected in buckets and exposed to strong smoke on a paddle-shaped piece of wood, which is alternately dipped in the milk and held over the fire. The same process has been applied in Brazil to the so-called Pernambuco or Mangabeira rubber (*Hancornia speciosa*) and succeeds also with Ceara, but it is now considered too slow and laborious. Some claim that the heat, after all, is the only effective part of it, and that the soot constitutes an undesirable impurity. Others insist that the acetic acid of the smoke causes the coagulation, and that the creosote preserves the rubber from decay. A weak solution of alum as a solidifying agent has been advocated, the surplus moisture incorporated between the adhering particles being removed by hydraulic or other strong pressure.

The Castilloa rubber of Central America is still more difficult to handle, two weeks or more being required for natural changes to bring about the separation of the gum. The natives store it during this period in specially prepared cavities in the ground, protected by by thatched roofs. A more usual, as well as a more expeditious practice, is to mix with the milk after it has been collected in barrels or other large receptacles a small proportion of the juice of the moonflower, *Ipomoea bona-nox*, a plant related to the morning glory. The action of the juice of this vine has been explained by Biffen on the ground that it is distinctly alkaline, thus counteracting the normal acidity of the juice of Castilloa, and causing the rapid separation of the rubber, a process just the reverse of what takes place in the Para rubber, which is naturally alkaline and requires acid to disturb its equilibrium. If the moonflower can not be obtained simple dilution with water will cause a slow separation of the Castilloa milk. Acetic acid has also been found effective and Hart even declares that the juice of the moonflower is not alkaline, but faintly acid.

Lime juice is used in West Africa with the latex of *Ficus vogelii*, and acetic acid with a species of Artocarpus, while common salt has succeeded with the juice of Hancornia, Manihot, and Hevea. Boiling is practiced on the latex of Mimusops, the balata tree of Venezuela. It has been found also that rubber may be obtained by purely mechanical means. By the aid of a centrifugal milk tester Biffen was able to separate the the rubber of Castilloa, Hevea, Manihot, Hancornia, and Mimusops, and even the gum of the bread-fruit tree; also a similar substance from a Brazilian fig, *Urostigma gamelleira*. Even the ordinary process of churning, as for butter, will cause the aggregation of the rubber globules. The

most recent suggestion for mechanical extraction is the trituration of the dried bark, twigs, or leaves, followed by repeated washings for the separation of the cellular tissue, leaving a compact mass of clean rubber.

From his experiments Biffen concluded that in the various processes the rubber itself is affected little or not at all, but that in the clotting or precipitation of the albuminous materials suspended in the latex the rubber globules are caught and held so that they can be further compacted and made to adhere. It seems, however, not entirely improbable that merely physical questions of specific gravity and surface tension may be involved. Obviously there must be a very fine adjustment of these relations in the normal latex or the rubber would compact itself and not remain in a homogeneous emulsion—if such an expression may be used. It is also plain that any of the processes alluded to, including simple evaporation, which is more or less effective with all kinds of latex, may disturb the relative density of the fluid or its components as compared with that of the rubber globules, which are probably the last to be affected. The process seems entirely analogous to the "flocculation" which takes place when clay or other finely divided matter suspended in a watery solution is precipitated by the addition of soluble inorganic salts, acids, or alkalies. Thus, muddy water may be cleared by a small percentage of a solution of lime, alum, or common salt. In some cases it is also true that a small amount of alkali (ammonia) serves, as in the Para rubber, to prevent flocculation, but too much has the opposite effect.

FUTURE OF RUBBER CULTURE.

Whatever the ultimate conclusions from these investigations and discoveries, the great diversity of opinion among students of the subject seems to indicate that we know extremely little about the constitution of latex or the best methods of extracting rubber, and we may be still far from the place where the invention of processes or appliances of permanent utility is to be expected. Proper manipulation may enable the extraction of rubber from juices not now utilized, so that a new process as well as a new plant might at any time revolutionize the whole subject of rubber culture. But while such a revolution would not destroy, it might gradually lessen, the value of producing trees, and by taking off the margin of profits, completely ruin the prospects and credit of enterprises based entirely on rubber. A realization of this fact, added to a knowledge of former failures, may account for the continued wariness of large investors, in spite of the inviting estimates so freely circulated.

The probability is thus increased that the future of rubber as a distinctly cultural industry will continue to lie in the direction of its development as contributory to the rise of mixed farming in the tropics, rather than in the organization of capital for the exploitation of a single product.

O. F. Cook,
Special Agent.

Approved:
James Wilson,
Secretary of Agriculture.

Washington, D. C., *June 22, 1900.*

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